Historic, archived document

Do not assume content reflects current scientific knowledge, policies, or practices.

CIRCULAR No. 405 OCTOBER 1936
UNITED STATES DEPARTMENT OF AGRICULTURE
WASHINGTON, D. C.

SUSCEPTIBILITY OF GRAPE ROOTSTOCKS TO ROOT KNOT NEMATODE

By Elmer Snyder, *pomologist, Division of Fruit and Vegetable Crops and Diseases, Bureau of Plant Industry*

CONTENTS

	Page		Page
Introduction	1	Susceptibility of grape rootstock varieties	7
Cause and nature of nematode injury	1	Summary	15
Susceptibility of *vitis vinifera* varieties	6		

INTRODUCTION

The root knot nematode (*Heterodera marioni* (Cornu) Goodey) is fast becoming one of the important destructive pest diseases of *Vitis vinifera* varieties of grape.s Under favorable soil, moisture, and temperature conditions, the root knot nematode causes a decided weakening of growth and a rapid decrease in production in vinifera grape vineyards, especially on sandy soil.

Figure 1 shows a spot of missing vines caused by nematode injury. Vineyards established before the soil became infested with the root knot nematode have been able. to survive for a considerable period. Weakening of growth and loss of production have eventually resulted in the pulling out of such vineyards after their commercial value was ruined by nematode injury. A 12-year-old vinifera vine is shown in figure 2. This vine was pulled from the soil by hand after very severe nematode injury. In some cases attempts have been made to replant vinifera vineyards in infested-soil areas. These replanted vineyards have failed to come into bearing. Figure. 3 shows a 2-year-old Sultanina (Thompson Seedless) vine very severely infested with nematodes after it had been planted in an infested soil. The failure of such young plantings has indicated the need of studies to ascertain if some of the phylloxera-resistant grape rootstocks might be of value for nematode resistance.

CAUSE AND NATURE OF NEMATODE INJURY

The root knot of the grape is caused by the nematode known as *Heterodera marioni* (Cornu) Goodey. The larva of this nematode is a minute, slender, worm-shaped animal hatched from an egg (fig. 4, *A*) laid inside the root. The male and female are similar in the larval stage. Just prior to the adult stage, sex differentiation occurs.

68974°—36

FIGURE 1.—A spot of missing vines caused by nematode injury.

FIGURE 2.—A 12-year-old vine destroyed by nematode infestation.

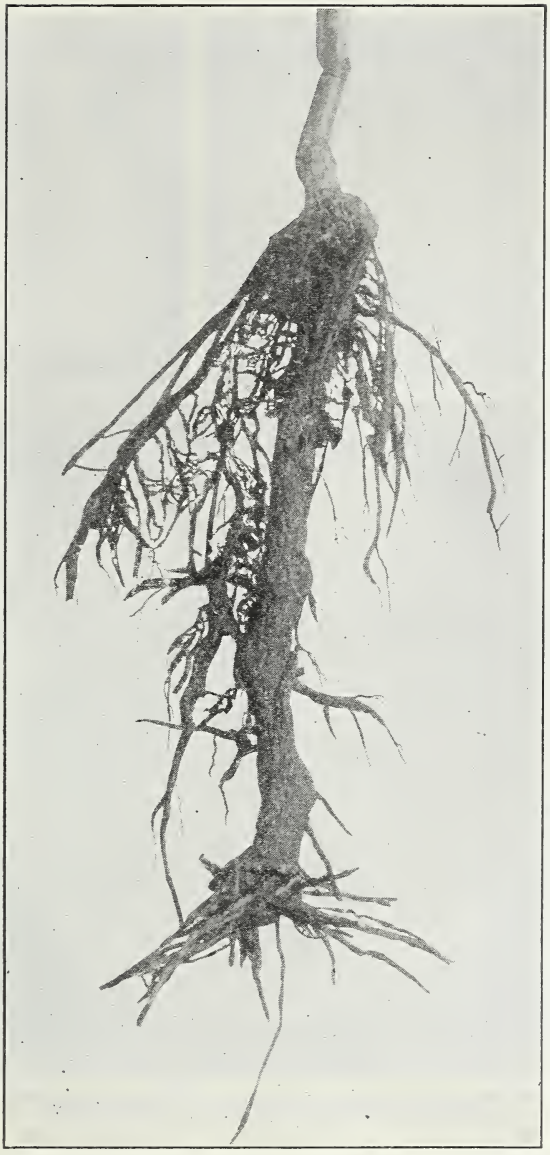

FIGURE 3.—A 2-year-old Sultanina vine very severely infested with the root knot nematode.

The female changes to a roundish pear-shaped form (fig. 4, *B*), while the male remains worm-shaped.

Figure 4, *C*, shows the eggs of the nematode and the newly hatched worms highly magnified. A single female may lay 500 or more eggs.

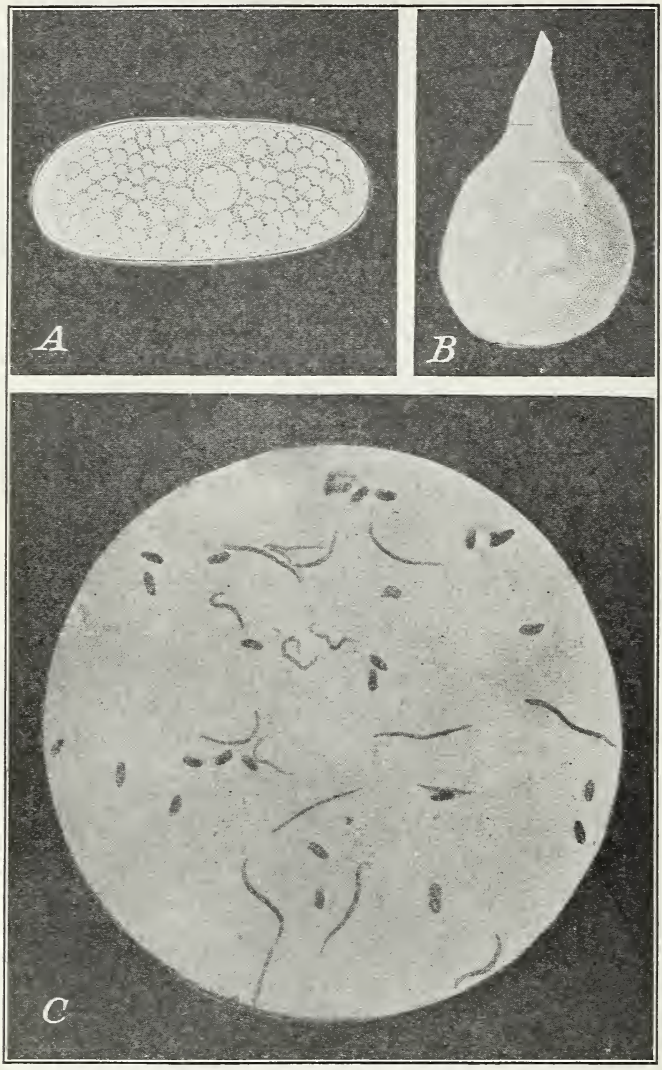

FIGURE 4.—*A*, Newly deposited egg, magnified 400 times; *B*, female nematode (*Heterodera marioni*), magnified 85 diameters; *C*, illustration made from a microphotograph of the eggs of the nematode and the worms just hatched.

The larvae may be quite active in the soil from which they penetrate the young rootlets. In some cases when the eggs hatch within the root, the larvae may work their way through the root tissue some distance from the place where they were hatched. Abnormal cell

growth takes place when the roots are infested, which results in characteristic swellings on the roots when the larvae are present in large numbers. Such swellings (fig. 5, *A*) caused by nematodes usually cause enlargement of the whole root while the nodosities caused by phylloxera have the swellings mostly on one side of the root and make a hook-shaped knot (fig. 5, *B*). Often a series of

FIGURE 5.—*A*, Characteristic root knot swellings caused by the nematode *Heterodera marioni*; *B*, characteristic nodosities caused by phylloxera.

knots caused by nematodes occurs on one root, somewhat resembling a string of beads. The size and number of swellings depend largely upon the number of nematodes present and may vary with the species of grape. The fact that some species are less susceptible than others forms a basis for the study of stocks resistant to nematode infestation.

The presence of root knot on grapes can easily be determined by examining a portion of the root system. On *Vitis vinifera* varieties the swellings are usually numerous on infested plants, causing definite enlargement of the small and large roots accompanied by a general decay of the affected roots. While the roots become greatly enlarged at various locations, the growing tips become more noticeably enlarged and the terminal growth ceases. The knots occurring on larger roots are usually badly decayed.

SUSCEPTIBILITY OF VITIS VINIFERA VARIETIES

In order to study the susceptibility of *Vitis vinifera* grape varieties to nematode attack, five vines each of 154 varieties were planted at Shafter, Calif., in soil known to be heavily infested with nematodes. The vines were grown one season under infested conditions. The following is an alphabetically arranged list of the vinifera varieties tested:

Affenthaler, Agadia, Ah Saibe, Ajmi, Alicante Bouschet, Aneb-el-Cadi, Aramon, Askaree.

Barbarossa, Barbera, Barducci, Beclan, Bellino, Bermestia Violacea, Bicane, Black Prince, Black Shahanee, Blaney White, Blauer Portugeiser, Bondelaise, Bowood Muscat, Buccleugh, Burger.

Cabernet Sauvignon, Cefid, Ceskarg Charial, Chabach Chali Sar, Chani Rouge, Chouch Rose, Chasselas Ciotat, Chasselas Rose de Falleaux, Chasselas St. Bernard, Chauche Gris, Chauche Noir, Clairette a Gros Grain, Coarna Neagra, Corinthe a Gros Grain, Corinthe Blanc, Corinthe Rose, Coristano, Cornichon, Crabbs Burgundy.

Damas Rose, Dronkane.

Emperor.

Fajauni Jaune, Feher Som, Feher Zagos, Fintendo, Flame Tokay, Foster, Fredericton.

Gamay Teinturier, Goolabie, Gradiska, Green Hungarian, Grenache, Gros Blanc de Lausanne, Gros Colman, Gros Guillaume, Gros Verdot.

Hebron, Hunisa, Hycales.

Italia Elqui.

J'bai, Johannisberger, Jubeili.

Kadarka, Kasufi inti, Kechwechi Bleue, Kandihar, Khudud-ul-Banat, Kolner, Koshu, Kurtelaska.

Lal Cefid, Larien, Leani Zolo, Luglienga Nero.

Madeleine Angevine, Malaga, Malaga Rose, Malpay, Mamelon, Maraville de Malaga, Maskah, Mataro, Meslier Hatif, Meunier, Millenium, Mission, Mondeuse, Mourastel, Mourisco Bianca, Muscat Bonod, Muscat Capusines, Muscat Hamburg, Mukhkh-ul-Baghl.

Nasa Valentiana, Nebbiolo, Negra Elqui.

Ohanez, Opiman.

Pagadebito, Palarusa, Palomino, Panariti, Parc de Versailles, Paykanee Razuki, Persian No. 23, Petit Syrah, Peverella, Pinot St. George, Prune de Cazouls, Purple Damascus.

Quagliano, Quanque.

Red Hanepoot, Robin Noir, Rodites, Rose d'Italia, Roussaou.

Sahebi Charial, San Giovetto, Sauvignon Vert, Serine, Servan Blanc, St. Laurient, St. Macaire, Sultanina, Suri, Sylvaner.

Tanfi Rose, Tannat, Teneron, Traminer, Trentham Black, Trojka, Trousseau.

Umagum.

Valandova, Valdepenas, Verdel.

Walschriesling, White Tokay, Wilmot No. 16.

Zabalskanski, Zeine, Zinfandel, Zinzillosa.

After a growth of one season, the plants were dug and the roots examined. Very heavy nematode infestations were found on the roots of all varieties. Both small and large roots were infested, and the major portion of all roots were very badly rotted. Although some

variation in vigor of top growth was noted, none of the varieties gave indications of inherent resistance. Rated on a comparative basis of 100 as representing complete infestation, all varieties fell within the group of very severe infestation, with ratings from 76 to 100.

SUSCEPTIBILITY OF GRAPE ROOTSTOCK VARIETIES

Preliminary investigations were made with a few stocks planted in nematode-infested soil. At the end of one season, the roots of some stocks were found to be more heavily infested than others. The results of these preliminary studies led to more extensive tests on different soil locations with a larger number of rootstock varieties. Two main plots were located on different soil types, one known as Delano sand at Shafter, Calif., and the other as Madera sand at Fresno, Calif. Both soil locations were heavily infested with nematodes. The stock rootings, or in some cases cuttings, were planted in the spring in these nematode-infested soil locations and in addition nematode-infested grape roots were distributed in contact with the stock roots to be tested. The majority of stocks tested were allowed to grow for a period of 4 years in the same location. Inspection of the roots was made at the end of each growing season. The stock varieties were classified according to the infestation of knots on the root system.

Table 1 gives a summary of the data relative to the susceptibility of the different rootstocks to nematode injury. Columns 1 to 4 are self-explanatory. Column 5 gives the gradations of roots from thin to thick and from soft to hard. No definite correlation between character of roots and infestations was found. In column 6 the character of the infestations was rated from very slight to very severe, in accordance with the scarcity or abundance of root knot swellings and with the healthy or rotted condition of the root system. In column 7 a numerical rating is given to indicate the relative or comparative infestation of the root systems and denoting the susceptibility of the different stock roots to root knot injury. Zero indicates no infestation, and 100 indicates complete infestation of the roots as determined by the inspections.

In the field tests it was considered that nematodes might be attracted from the partially resistant stocks to the more susceptible varieties. To gain information additional to the field tests, duplicate sets of the more important stock rootings were planted in 5-gallon cans in soil taken from infested areas and also heavily inoculated with

TABLE 1.—*Comparative susceptibility of grape rootstocks to root knot nematode*

Grape rootstock variety	Extent of test			Character of root system	Character of infestation	Comparative rating of infestation
	Years	Plots	Vines			
	Number	*Number*	*Number*			
(*Vitis aestivalis* × *V. monticola*) × (*V. riparia* × *V. rupestris*), no. 554–5	4	2	58	Medium thick, medium hard	Very severe	90
Alicante Bouschet (*V. vinifera*) × *V. cordifolia*, no. 142–B	1	1	14	Medium thin, medium hard	Severe	75
Alicante Bouschet (*V. vinifera*) × *V. riparia*, no. 141–A	3	2	56	Medium thick, soft	Mild	40
Aramon (*V. vinifera*) × *V. rupestris*, Ganzin, no. 1	4	2	54	Thick, soft	Very severe	95
Aramon (*V. vinifera*) × *V. rupestris*, Ganzin, no. 2	4	2	49	do	do	90
Aramon (*V. vinifera*) × *V. rupestris*, Ganzin, no. 9	4	1	30	Medium thick, medium hard	do	95
Arizonica Phoenix (*V. arizonica*)	2	2	18	Thick, soft	do	80
Australis (*V. longii*)	4	2	63	Thin, hard	Slight	25
Barnes (*V. champini*)	4	2	58	Thick, soft	Very slight	5
Berlandieri, no. 1 (*V. berlandieri*)	1	1	2	Medium thick, soft	Mild	40
Berlandieri (*V. berlandieri*) Lafont, no. 9	1	1	2	do	Medium	60
V. berlandieri × Novo Mexicana (*V. candicans*), 31–R	1	1	20	Medium thick, medium hard	Severe	70
V. berlandieri × *V. riparia*, no. 34 E. M	4	2	43	Medium thick, soft	Medium	60
V. berlandieri × *V. riparia*, no. 420–A	4	2	69	Thin, hard	do	50
V. berlandieri × *V. rupestris metallica*, no. R–125	4	1	30	Medium thick, medium hard	Very severe	90
V. berlandieri × *V. rupestris* St. George, no. R–1742	4	1	30	Thin, medium hard	do	85
(Bourrisquou (*V. vinifera*) × *V. rupestris*, no. 601) × Calcicola, no. 13205	1	1	21	Thick, medium soft	do	85
Champanel (*V. champini* × *V. labrusca*)	1	1	12	Thick, medium hard	Mild	35
Chasselas (*V. vinifera*) × *V. berlandieri*, no. 41–B	4	2	61	Medium thick, medium soft	Very severe	85
Constantia (*V. rupestris*)	4	2	61	Thin, medium hard	Severe	75
V. cordifolia × *V. riparia*, no. 125–1	4	2	93	Medium thick, medium hard	Medium	45
Cynthiana (*V. aestivalis*)	1	1	3	do	do	60
De Grassett (*V. champini*)	1	1	14	Medium thick, medium soft	Very slight	10
Dog Ridge (*V. champini*)	4	2	45	Thick, medium soft	do	5
Judge (*V. doaniana*)	4	1	55	Thin, medium soft	Medium	60
Lenoir (*V. bourquiniana*)	5	2	64	Thick, medium soft	do	60
Millardet (*V. berlandieri*)	1	1	20	Thin, medium hard	do	60
V. monticola × *V. riparia*, no. 18804	4	1	30	Medium thick, medium hard	Severe	75
V. monticola × *V. riparia*, no. 18808	4	2	40	do	do	70
V. monticola × *V. riparia*, no. 18815	4	2	75	Medium thick, hard	Mild	40
V. monticola × *V. rupestris*	4	2	68	Thin, hard	Medium	60
Mourvedre (*V. vinifera*) × *V. rupestris*, no. 1202	4	2	85	Medium thick, medium soft	Severe	75
Muench (*V. bourquiniana* × *V. lincecumii*)	1	1	11	Thick, soft	Slight	25
Neosho (*V. lincecumii*)	1	1	10	Medium thick, medium soft	do	25
Ramsey (*V. champini*)	1	1	2	Medium thick, soft	do	25
Riparia Gloire (*V. vulpina*)	4	2	49	Thin, medium soft	Medium	55
V. riparia × *V. berlandieri*, no. 161–49	4	2	56	do	do	45
V. riparia × (*V. cordifolia* × *V. rupestris*), no. 106–8	4	2	78	Medium thick, medium hard	Mild	30
V. riparia × *V. rupestris*, no. 101	4	2	51	do	Medium	45
V. riparia × *V. rupestris*, no. 101–14	4	2	56	Medium thin, medium hard	do	45

V. riparia × *V. rupestris*, no. 3306	4	2	76	Thin, medium hard	Medium	60
V. riparia × *V. rupestris*, no. 3309	4	2	54	do	do	50
V. riparia × *V. rupestris*, no. 108–103	4	2	47	Thin, medium soft	Severe	65
V. riparia × *V. rupestris*, no. P–2A	4	1	30	Thick, medium soft	Very severe	90
V. rupestris des Semis, no. 81–2	2	1	43	Thick, soft	do	85
V. rupestris Othello ((*V. riparia* × *V. labrusca*) × *V. vinifera*)	4	1	30	Medium thin, hard	do	85
V. rupestris Pillans	4	2	60	Thin, hard	do	85
V. rupestris St. George	4	2	68	do	Severe	75
V. rupestris × *V. berlandieri*, no. 110–R	1	1	4	Medium thick, soft	Very severe	80
V. rupestris × *V. berlandieri*, no. 219–A	4	2	67	Thin, medium soft	Severe	75
V. rupestris × *V. berlandieri*, no. 301–A	4	2	53	Medium thick, medium hard	Medium	50
V. rupestris × *V. cinerea*	4	2	65	Medium thin, hard	Slight	15
V. rupestris × *V. cordifola*, no. 107–11	4	2	72	Thin, hard	Medium	45
V. rupestris × *V. riparia*, no. 108–16	4	1	30	Thin, medium soft	Slight	20
Salt Creek (*V. doaniana*)	4	2	55	Thin, hard	Very slight	5
Solonis (*V. longii*) × *V. cordifola* × *V. rupestris*, no. 202–4	4	2	30	Thick, medium hard	Medium	45
Solonis (*V. longii*) × Othello ((*V. riparia* × *V. labrusca*) × *V. vinifera*), no. 1613	5	2	70	Medium thin, hard	Very slight	5
Solonis (*V. longii*) × *V. riparia*, no. 1616	5	2	79	Thin, medium hard	do	10
Vermorel (*V. champini*)	1	1	20	Medium thick, medium soft	Slight	25
V. californica	3	2	34	Thick, soft	Medium	55

grape roots infested with nematodes. With some of the stocks these tests were duplicated 2 years. At the end of the growing season, the

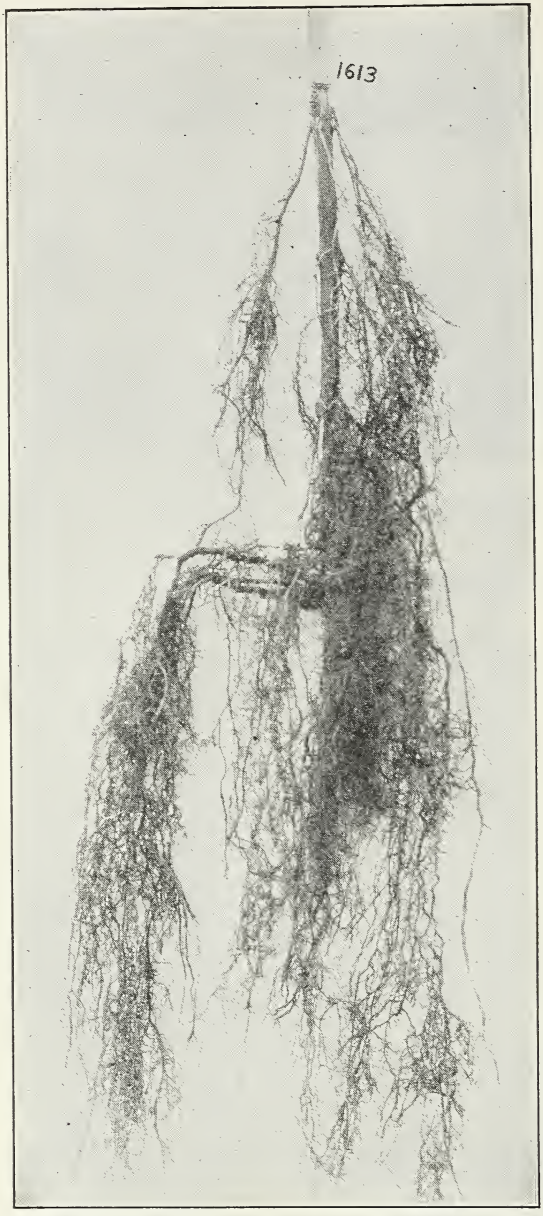

FIGURE 6.—A rooting of Solonis × Othello, no. 1613, after growing 1 year in a 5-gallon can in soil inoculated with nematode-infested roots. Infestation rating of 5, indicating no apparent injury.

soil was washed from the cans, the roots were inspected, and the infestations recorded. Figure 6 shows a rooting of Solonis × Othello,

no. 1613, after growing 1 year in a 5-gallon can in infested soil and also inoculated with nematode-infested grape roots. Rupestris St. George

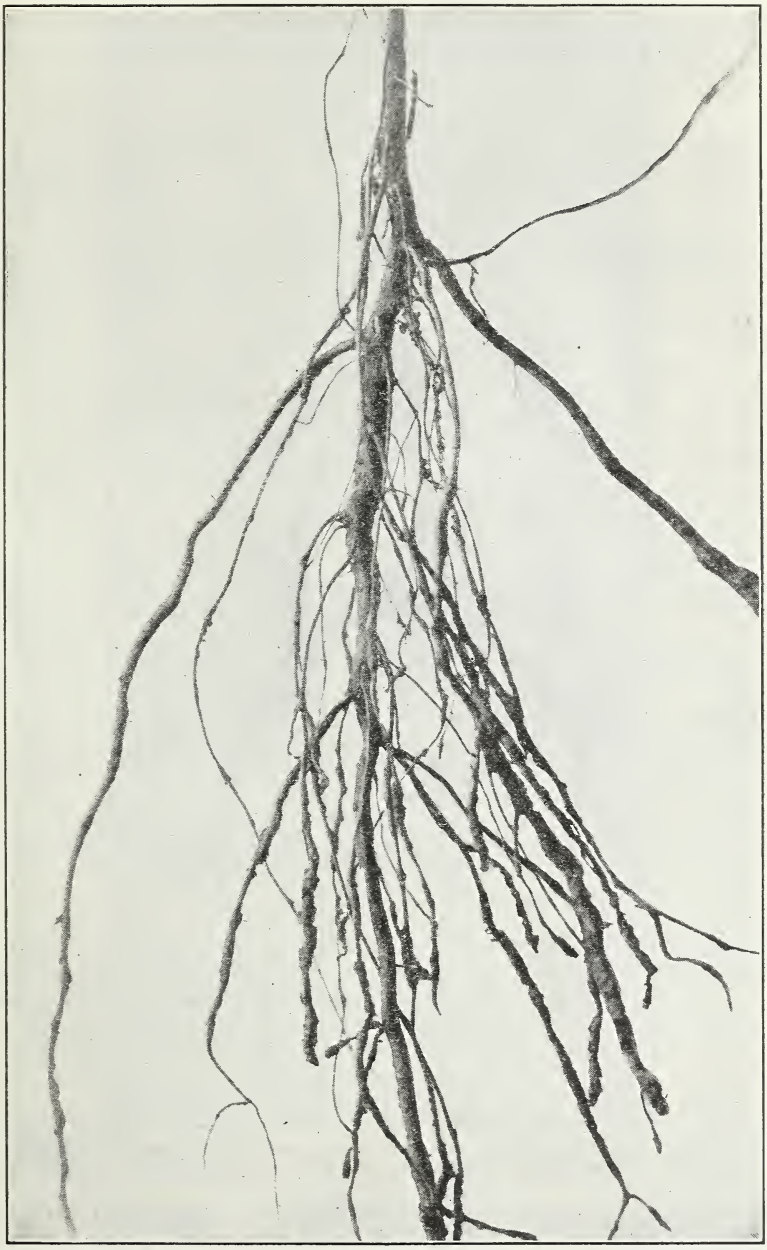

FIGURE 7.—Rupestris St. George roots badly infested with nematode, indicating a comparative infestation rating of 75.

roots were badly infested with nematodes during the same period. A portion of the root system is shown in figure 7. After 1-year's growth

in a 5-gallon can, Chasselas × Berlandieri, no. 41–B, was very severely affected, as shown in figure 8.

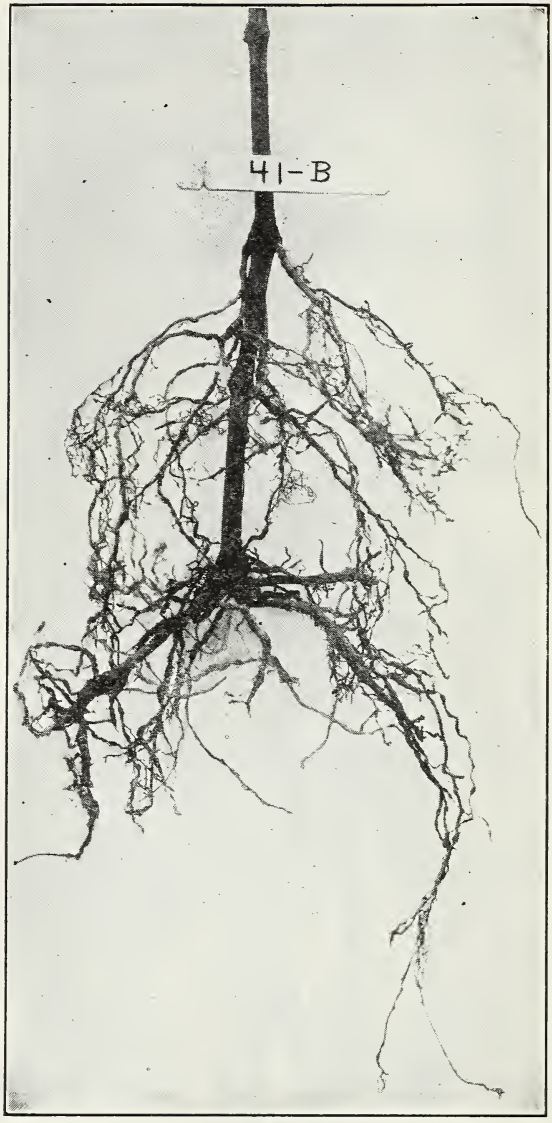

FIGURE 8.—Chasselas × Berlandieri, no. 41–B, after 1-year's growth in a 5-gallon can in soil inoculated with nematode-infested roots, the infestation rating of 85 indicating very serious root injury.

Table 2 gives a summary of the comparative susceptibility of grape rootstocks to the root knot nematode when grown in 5-gallon cans and inoculated with nematode-infested roots.

TABLE 2.—*Comparative susceptibility of grape rootstocks to the root knot nematod when grown in 5-gallon cans and inoculated with nematode-infested roots*

Variety	Years	Vines	Comparative rating of infestation	Character of infestation
	Number	*Number*		
Alicante Bouschet (*Vitis vinifera*) × *V. riparia*, no. 141–A.	1	2	40	Mild, some of fine roots infested.
Aramon (*V. vinifera*) × *V. rupestris*, Ganzin, no. 2.	1	2	90	Very severe, very heavy infestation on most roots.
Arizonica Phoenix (*V. arizonica*)	1	2	80	Very severe, heavy infestation on most roots.
Australis (*V. longii*)	1	2	25	Slight, few small roots infested.
V. berlandieri, Lafont no. 9	1	2	60	Medium, heavy infestation on small roots, some on large roots.
V. berlandieri × *V. riparia*, no. 420–A	2	4	50	Do.
Chasselas (*V. vinifera*) × *V. berlandieri*, no. 41–B.	1	2	85	Very severe, very heavy infestation on all roots.
Constantia (*V. rupestris*)	1	2	75	Severe, heavy infestation on small and large roots.
V. cordifolia × *V. riparia*, no. 125–1	1	2	50	Medium, heavy infestation on small, few on large roots.
Dog Ridge (*V. champini*)	1	2	5	Very slight, very few infestations on small roots.
Lenoir (*V. bourquiniana*)	1	2	85	Very severe, very heavy infestation on most roots.
V. monticola × *V. riparia*, no. 18808	1	2	70	Severe, medium-heavy infestation on most roots.
V. monticola × *V. riparia*, no. 18815	2	4	40	Mild, medium infestation on small roots, few on large roots.
V. monticola × *V. rupestris*	2	4	60	Medium, medium-heavy infestation on small roots, few on large roots.
Mourvedre (*V. vinifera*) × *V. rupestris*, no. 1202.	2	12	75	Severe, heavy infestation on small and large roots.
Ramsey (*V. champini*)	1	2	25	Slight, few infestations on small roots.
Riparia Gloire (*V. vulpina*)	2	4	55	Medium, medium-heavy infestation on small roots.
V. riparia × *V. rupestris*, no. 101	1	2	50	Do.
V. riparia × *V. rupestris*, no. 3309	1	2	55	Medium, medium-heavy infestation on small and medium roots.
Rupestris St. George (*V. rupestris*)	2	4	80	Very severe, heavy infestation on most roots.
V. rupestris × *V. berlandieri*, no. 219–A	1	2	75	Severe, heavy infestation on small and large roots.
V. rupestris × *V. cinerea*	1	2	15	Slight, slight infestation on fine roots.
V. rupestris × *V. cordifolia*, no. 107–11	1	2	45	Medium, medium heavy infestation on small roots.
Salt Creek (*V. doaniana*)	2	4	5	Very slight, very few infestations on small fine roots.
Solonis (*V. longii*) × Othello ((*V. riparia* × *V. lubrusca*) × *V. vinifera*), no. 1613.	2	4	5	Do.
Solonis (*V. longii*) × *V. riparia*, no. 1616	1	2	10	Very slight, few infestations on small roots.

From the data given in tables 1 and 2, the grape rootstocks have been grouped below according to their comparative susceptibility to root knot infestations as determined by these trials.

Group 1 includes grape rootstocks with infestation ratings from 0 to 10. The stocks in this group were only slightly infested on the fine roots, and the top growth apparently was not checked.

Barnes (*Vitis champini*).
De Grassett (*V. champini*).
Dog Ridge (*V. champini*).
Salt Creek (*V. doaniana*).
Solonis (*V. longii*) × Othello ((*V. riparia* × *V. labrusca*) × *V. vinifera*), no. 1613.
Solonis (*V. longii*) × *V. riparia*, no. 1616.

Group 2 includes grape rootstocks with infestation ratings from 11 to 25. The stocks in this group were only slightly infested on the small roots, causing some rotting on the tips of the fine roots. The top growth was only slightly checked.

Australis (*V. longii*).
Muench (*V. bourquiniana* × *V. lincecumii*).
Neosho (*V. lincecumii*).
Ramsey (*V. champini*).
V. rupestris × *V. cinerea*.
V. rupestris × *V. riparia*, no. 108–16.
Vermorel (*V. champini*).

Group 3 includes grape rootstocks with infestation ratings from 26 to 40. The stocks in this group were quite heavily infested on the fine roots, and a few swellings were found on some of the larger roots. Rotting was quite apparent on the roots and the top growth was checked.

Alicante Bouschet (*V. vinifera*) × *V. riparia*, no. 141–A.
Berlandieri (*V. berlandieri*), no. 1.
Champanel (*V. champini*, *V. labrusca*).
V. monticola × *V. riparia*, no. 18815.
V. riparia × *V. cordifolia* × *V. rupestris*, no. 106–8.

Group 4 includes grape rootstocks with ratings from 41 to 60. The stocks in this group had a medium heavy infestation on the fine roots and some swellings on the larger roots, with very apparent checking of the root and top growth.

Berlandieri (*V. berlandieri*), Lafont no. 9.
V. berlandieri × *V. riparia*, no. 34 E. M.
V. berlandieri × *V. riparia*, no. 420–A.
V. cordifolia × *V. riparia*, no. 125–1.
Cynthiana (*V. aestivalis* × *V. labrusca*).
Judge (*V. doaniana*).
Lenoir (*V. bourquiniana*).
Millardet (*V. berlandieri*).
V. monticola × *V. rupestris*.
Riparia Gloire (*V. vulpina*).
V. riparia × *V. berlandieri*, no. 161–49.
V. riparia × *V. rupestris*, no. 101.
V. riparia × *V. rupestris*, no. 101–14.
V. riparia × *V. rupestris*, no. 3309.
V. riparia × *V. rupestris*, no. 3306.
V. rupestris × *V. berlandieri*, no. 301–A.
V. rupestris × *V. cordifolia*, no. 107–11.
Solonis (*V. longii*) × *V. cordifolia* × *V. rupestris*, no. 202–4.
V. californica.

Group 5 includes grape rootstocks with infestation ratings from 61 to 75. The stocks in this group had a heavy infestation on the fine roots; the large roots were infested and showed decided rotting. The top growth was decidedly dwarfed.

Alicante Bouschet (*V. vinifera*) × *V. cordifolia*, 142–B.
V. berlandieri × Novo Mexicana (*V. candicans*), no. 31–R.
Constantia (*V. rupestris*).
V. monticola × *V. riparia*, no. 18804.
V. monticola × *V. riparia*, no. 18808.
Mourvedre (*V. vinifera*) × *V. rupestris*, no. 1202.
V. riparia × *V. rupestris*, no. 108–103.
Rupestris St. George (*V. rupestris*).
V. rupestris × *V. berlandieri*, no. 219–A.

Group 6 includes grape rootstocks with infestation ratings from 76 to 100. The stocks in this group were heavily infested on the small and large roots and showed very serious rotting on the major portion of the root system. Very little top growth was made by the stocks included in this group.

V. aestivalis × *V. monticola* × *V. riparia* × *V. rupestris*, no. 554–5.
Aramon (*V. vinifera*) × *V. rupestris*, Ganzin, no. 1.
Aramon (*V. vinifera*) × *V. rupestris*, Ganzin, no. 2.
Aramon (*V. vinifera*) × *V. rupestris*, Ganzin, no. 9.
Arizonica Phoenix (*V. arizonica*).
V. berlandieri × *V. rupestris metallica*, no. R–125.
V. berlandieri × *V. rupestris*, St. George no. R–1742.
Chasselas (*V. vinifera*) × *V. berlandieri*, no. 41–B.
V. riparia × *V. rupestris*, no. P–2A.
V. rupestris des Semis, no 81–2.
V. rupestris Othello ((*V. riparia* × *V. labrusca*) × *V. vinifera* ?).
V. rupestris pillans.
V. rupestris × *V. berlandieri*, no. 110–R.
Bourrisquou (*V. vinifera*) × *V. rupestris*, no. 601 × Calcicola, no. 13205.

Commercial plots (fig. 9) have been established on nematode-infested soils to determine definitely the relative value of the most resistant kinds as stocks under vineyard conditions.

SUMMARY

Commercial vinifera vineyards have been seriously injured by root knot nematodes. From the tests described in this report, 154 varieties of *Vitis vinifera* were found to be very susceptible to root knot infestation. Very heavy infestations occurred on all vinifera varieties even during one growing season when the vines were planted in nematode-infested soil.

From the data recorded in tables 1 and 2, the majority of the American species and hybrids included in these tests were too seriously affected to be considered of further value as nematode-resistant stocks.

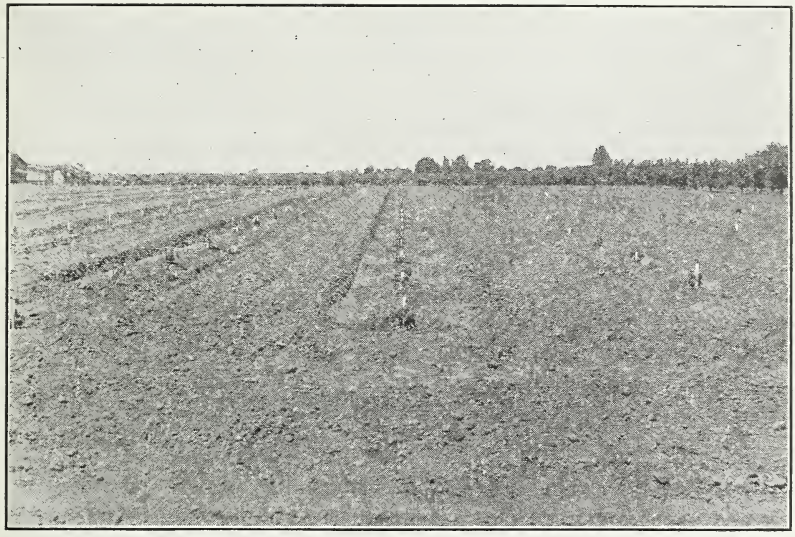

FIGURE 9.—A commercial test plot established on nematode-infested soil.

None of the stock varieties were found to be immune to nematode attack. However, the tests indicate that certain grape species may have some inherent resistance to nematode injury. Stock varieties of *Vitis doaniana*, *V. champini*, *V. longii*, and *V. cinerea* appear the most promising.

Some of these stock varieties and their hybrids were only very slightly affected and appear sufficiently resistant to nematode attack to merit commercial trials. These stocks are given in group 1, namely, Barnes, De Grassett, Dog Ridge (all of the Champini species), Salt Creek (*Vitis doaniana*), and the two *V. longii* hybrids, Solonis × Othello, no. 1613, and Solanis × *V. riparia*, no. 1616. Of these stocks, Dog Ridge, Salt Creek, and Solonis × Othello, no. 1613, have been selected on account of their vigor and general adaptability for further trials.

ORGANIZATION OF THE UNITED STATES DEPARTMENT OF AGRICULTURE WHEN THIS PUBLICATION WAS LAST PRINTED

Secretary of Agriculture	HENRY A. WALLACE.
Under Secretary	REXFORD G. TUGWELL.
Assistant Secretary	M. L. WILSON.
Director of Extension Work	C. W. WARBURTON.
Director of Finance	W. A. JUMP.
Director of Information	M. S. EISENHOWER.
Director of Personnel	W. W. STOCKBERGER.
Director of Research	JAMES T. JARDINE.
Solicitor	MASTIN G. WHITE.
Agricultural Adjustment Administration	H. R. TOLLEY, *Administrator.*
Bureau of Agricultural Economics	A. G. BLACK, *Chief.*
Bureau of Agricultural Engineering	S. H. MCCRORY, *Chief.*
Bureau of Animal Industry	JOHN R. MOHLER, *Chief.*
Bureau of Biological Survey	IRA N. GABRIELSON, *Chief.*
Bureau of Chemistry and Soils	HENRY G. KNIGHT, *Chief.*
Commodity Exchange Administration	J. W. T. DUVEL, *Chief.*
Bureau of Dairy Industry	O. E. REED, *Chief.*
Bureau of Entomology and Plant Quarantine	LEE A. STRONG, *Chief.*
Office of Experiment Stations	JAMES T. JARDINE, *Chief.*
Food and Drug Administration	WALTER G. CAMPBELL, *Chief.*
Forest Service	FERDINAND A. SILCOX, *Chief.*
Bureau of Home Economics	LOUISE STANLEY, *Chief.*
Library	CLARIBEL R. BARNETT, *Librarian.*
Bureau of Plant Industry	FREDERICK D. RICHEY, *Chief.*
Bureau of Public Roads	THOMAS H. MACDONALD, *Chief.*
Soil Conservation Service	H. H. BENNETT, *Chief.*
Weather Bureau	WILLIS R. GREGG, *Chief.*

This circular is a contribution from

Bureau of Plant Industry	FREDERICK D. RICHEY, *Chief.*
Division of Fruit and Vegetable Crops and Diseases.	E. C. AUCHTER, *Principal Horticulturist, in Charge.*

16

U. S. GOVERNMENT PRINTING OFFICE: 1936

For sale by the Superintendent of Documents, Washington, D. C. - - - - - Price 5 cents